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Manager of
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February 28, 2004

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: **Docket Nos. 50-361 and 50-362 Response to First Revised NRC Order (EA-03-009) Issued February 20, 2004 and Additional Information Regarding Relaxation Requests 1 and 2 for Reactor Pressure Vessel Head Penetration Inspection Requirements for San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 (TAC Nos. MC1540, MC1541, MC1542, and MC1543)**

References: Enclosure 1

Dear Sir or Madam,

This letter transmits Southern California Edison (SCE) Company's response to First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Vessel Heads at Pressurized Water Reactors, issued on February 20, 2004, and SCE's responses to NRC questions regarding Relaxation Request 2. This letter also withdraws Relaxation Request 1. These relaxation requests were submitted to the NRC by letter dated December 9, 2003 (Reference 1). SCE provided additional information for these requests and WCAP-15819 Rev. 1 by letter dated February 9, 2004 (Reference 2).

SCE consents to the First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Vessel Heads at Pressurized Water Reactors, Issued on February 20, 2004, and submits the enclosed Relaxation Request (Relaxation Request 2, Revision 1).

Relaxation Request 2 addresses inaccessible areas with respect to non-destructive examinations. The response to the NRC's request for additional information regarding Relaxation Request 2 is provided in Enclosures 2 and 3 and a superceding version of Relaxation Request 2 is provided in Enclosure 4.

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Based on a review of the First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Vessel Heads at Pressurized Water Reactors, issued on February 20, 2004, SCE has determined that Relaxation Request 1 is no longer required. Therefore, SCE withdraws Relaxation Request 1.

SCE requests approval of Relaxation Request 2 for inspections of SONGS Units 2 and 3 reactor vessel heads performed to meet the requirements of Reference 3 until rescinded by the NRC or withdrawn by SCE.

SCE requests approval of Relaxation Request 2, Revision 1 as soon as possible. SCE is currently inspecting the SONGS Unit 2 reactor vessel head and is currently scheduled to complete these inspections on March 1, 2004.

Should you have any questions, please contact Mr. Jack Rainsberry at (949) 368-7420.

Sincerely,

Enclosures

cc: B. S. Mallett, Regional Administrator, NRC Region IV
B. M. Pham, NRC Project Manager, San Onofre Units 2, and 3
C. C. Osterholtz, NRC Senior Resident Inspector, San Onofre Units 2 & 3

Enclosure 1

References:

1) Letter from A. E. Scherer (SCE) to the Document Control Desk (NRC) Dated December 9, 2003; Subject: Docket Nos. 50-361 and 50-362, Request For Relaxation Of Reactor Pressure Vessel Head Penetration Inspection Requirements In Nuclear Regulatory Commission Order EA-03-009, San Onofre Nuclear Generating Station Units 2 and 3

2) Letter from A. E. Scherer (SCE) to the Document Control Desk (NRC) Dated February 9, 2004; Subject: Response to NRC Request for Additional Information Regarding Relaxation Requests 1 and 2 for Reactor Pressure Vessel Head Penetration Inspection Requirements in Nuclear Regulatory Commission Order EA-03-009 for San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 (TAC Nos. MC1540, MC1541, MC1542, and MC1543)

3) First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Vessel Heads at Pressurized Water Reactors, issued on February 20, 2004

Enclosure 2

Additional Information Supporting SCE Relaxation Request 2 to First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors

<u>Responses to NRC Questions</u>

Enclosure 2

Responses to NRC Questions

Introduction

Southern California Edison (SCE) previously submitted Relaxation Request 2 requesting a reduced inspection coverage area defined from 2 inches above the top of the weld to the minimum required inspection distance below the bottom of the weld as determined by supporting fracture mechanics analyses. Although the revised Order requirements reduce the required inspection distance below the bottom of the weld, relaxation is still required for the SONGS Units 2 and 3 reactor heads. Relaxation is now requested from the requirement to inspect to one inch below the weld inclusive of all surfaces with greater than 20 ksi tensile stress. In all cases, SCE will meet the order requirements, or will inspect as far down the nozzle as possible. Where the requirement to inspect to one inch below the toe of the weld cannot be met due to physical interference from threads, fracture mechanics analyses have been performed to demonstrate that postulated cracks in the un-inspected area will not propagate to the bottom of the J-groove weld before the next inspection. Therefore, the proposed alternative to inspect over a reduced inspection area from 2 inches above the weld to as far down as possible (which will exceed the minimum required inspection distance below the bottom of the weld for all CEDM nozzles) provides an acceptable level of quality and safety.

NRC Question 1

The staff has reviewed WCAP-15819 Rev. 1. The licensee is requested to explain how the hoop stress in Appendix B was used to develop the curve in Appendix C. Specifically, at 49.7, which is the most limiting distance in your table representing Control Element Drive Mechanisms (CEDMs) 88-91, the period for which the crack will grow into the weld does not appear to support 1 outage period. Please clarify.

SCE Response to Question 1

Enclosure 3 provides an example of the calculation method used to generate the crack growth curves presented in both Section 6 and Appendix C of WCAP-15819, Rev. 1 including a description of how the hoop stress in Appendix B was used to develop the curves.

The minimum inspection distance that precludes an undetected crack from propagating to the toe of the J-groove weld during one cycle of operation can be extracted from the crack growth curves presented in Section 6 and/or Appendix C. This is done by finding the point at which the curve intersects the bottom of the weld, determining the effective full power years (EFPY) value associated with that point, subtracting 1.75 years from that EFPY, then find the distance below the weld associated with the smaller EFPY value. SCE conservatively used 21 months (1.75 year) in all cases when determining the minimum required inspection distance below the weld, which is longer than a typical SONGS cycle. The procedure described above is illustrated in Example Problem #5, which is found on page 7-3, summarized on page 7-5 with the solution shown on page 7-11 of WCAP-15819, Rev. 1.

The requested relaxation of inspection distances below the J-groove weld that were provided in response to Question 2 of Enclosure 3 of Reference 2 were based on the crack growth curves provided in figures 6-12 through 6-17 of WCAP-15819, Rev. 1. The postulated initial crack for these curves extends from below the expected lower extent of the inspection coverage area to the point where hoop stresses on both the ID and the OD are less than 20 ksi. This assumption is conservative since primary water stress corrosion cracking (PWSCC) has not been observed at this stress level without substantial coincident cracking within the inspection coverage area. The requested relaxation does support one operating period between examinations when the WCAP-15819, Rev. 1 Section 6 curves are employed.

WCAP-15819, Rev.1 also provides a family of crack growth rate curves in Appendix C. The postulated initial crack for the Appendix C curves extends from below the expected lower extent of the inspection coverage area to the point where hoop stresses on either the ID or the OD are no longer tensile. This is the only change in the method used to construct the Appendix C crack growth curves relative to the Section 6 crack growth curves. Both Section 6 and Appendix C use design weld sizes, which is conservative compared to the as-built weld sizes, as shown in a summary table on page 5 of Enclosure 3.

The Appendix C curves were not used to determine minimum inspection distances in the previous SONGS Relaxation Request. The application of the Appendix C crack growth curves results in slightly larger minimum required inspection distances below the weld to support operation for one SONGS fuel cycle. The following table illustrates the differences in minimum required inspection distance below the J-groove weld when Appendix C is used.

SCE revises Relaxation Request 2 to apply the minimum inspection distances in accordance with Appendix C, as shown in the table below (see Enclosure 4 for revised Relaxation Request 2).

Minimum Inspection Distances Below the Toe of the J-groove Weld

Penetration(s)	WCAP-15819, Rev. 1 Section 6 (Retracted Request)	WCAP-15819, Rev. 1 Appendix C (Requested Relaxation)
CEDM # 1	0.44 inches	0.44 inches
CEDM #'s 2 - 35	0.41 inches	0.43 inches
CEDM #'s 36 - 87	0.30 inches	0.42 inches
CEDM #'s 88 - 91	0.24 inches	0.35 inches

NRC Question 2

The licensee is requested to provide additional curves in Appendix C to support the unidentified angles of the CEDMs identified in the table provided in response to RAI dated February 9, 2004 (i.e., 11 , 15.6 , 17.6 etc.). From the staff's evaluation, it appears that there are some CEDM's which would not be able to support a crack until the next scheduled outage. Additional examinations of these CEDMs would then be required.

SCE Response to Question 2

The two rows of penetrations nearest the head flange, which is the region where cracking has been discovered in other non-B&W design plants, were analyzed in WCAP-15819, Rev. 1. In addition, an intermediate row of penetrations and the center CEDM penetration were analyzed to provide additional results, so that a trend could be established as a function of angular position of the head penetration nozzles. As shown in Appendix C, Figures C-1 to C-4 of WCAP-15819 Rev. 1, for the same inspection coverage on the downhill side of the CEDM penetration, i.e. 0.5 inch below the weld, a trend can be observed that the time for the crack to reach the bottom of the weld increases as the angular position of the CEDM penetration increases. Based on the observed trend, SONGS conservatively chose to impose inspection requirements based on the most limiting CEDM angular position within each set of penetration nozzles, as shown in the response to Question 1. Therefore, the crack growth curves provided in WCAP-15819, Rev. 1 for the four selected rows of CEDM penetration nozzles can be conservatively used to determine the minimum inspection coverage required for those CEDM penetration nozzles not being evaluated in WCAP-15819 Rev. 1. Note that the ICI penetration geometry is different from the CEDM configuration and the crack growth curves were generated separately for the ICI nozzles.

NRC Question 3

The licensee is requested to provide the K value for Figures 6-12 through 6-17 and in Appendix C. Explain and describe the methodology as to how K was calculated.

SCE Response to Question 3

An iterative process is used in generating the crack growth curves. The stress intensity factor "K" for each subsequent iterative upper crack tip location as the crack propagates is determined by using the updated hoop stress (σ) at the new upper crack tip location and the new half flaw length (a). The hoop stress used increases as the flaw propagates upward towards the bottom of the weld as shown in the hoop stress distribution in Appendix B. A period of one month is used for each iterative step.

Enclosure 3 provides a detailed explanation and an example of the methodology used in calculating the stress intensity factor "K". The same methodology was used in calculating the K values for the crack growth curves shown in both Figures 6-12 through 6-17 and in Appendix C. Since the K value changes as the stress level and flaw size vary during the crack growth calculation, it is not practical to present all the K values calculated as requested. However, the example calculation in Enclosure 3 provides the K value for the initial axial through-wall flaw postulated in the center penetration nozzle. This K value was used as the initial K value in the generation of the crack growth curve shown in Figure C-1. The K value at any point on the crack growth curve can then be obtained using the methodology illustrated in Enclosure 3 by using the corresponding crack length and stress level.

NRC Question 4

The licensee is requested to provide in detail a summary and conclusion from the evaluation of WCAP-15819, Rev. 1 to support their relief request that additional inspections are not required and that if cracks were formed at the minimum distance below the weld the time to propagate to the toe of the J-groove weld would take longer than the next scheduled outage. The crack growth evaluation needs to be in accordance with Appendix C.

SCE Response to Question 4

Purpose:

WCAP-15819, Rev. 1 provides the technical justification for the continued safe operation of San Onofre Units 2 and 3 in the event that cracking is discovered during in-service inspections of the Alloy 600 reactor vessel upper head penetrations. The results of the calculations presented in WCAP-15819, Rev. 1 can be used for postulated cracks as well as actual cracks identified during inspection activities. The postulated flaw tolerance evaluation for an axial through-wall flaw located below the inspection coverage area provides the basis to define the minimum requested inspection distance below the toe of the weld to show that any undetected cracks below the inspected region would not propagate to the toe of the weld before the next scheduled outage.

An extensive evaluation was carried out to characterize the loadings and stresses, which exist in the penetrations of the San Onofre Units 2 and 3 reactor vessel heads. Three-dimensional finite element models were constructed, and all pertinent loadings on the penetrations were analyzed. These loadings included internal pressure and thermal expansion effects typical of steady state operation. In addition, residual stresses due to the welding of the penetrations to the vessel head were considered.

Overall Technical Approach:

In Section 3 of WCAP-15819, Rev. 1 the overall technical approach is discussed. A flaw tolerance approach was developed to define the time available for continued safe operation until a repair would be required. In some cases the flaw configuration is acceptable until the end of plant life. The "allowable" flaw size is determined from the actual loading (including operating and residual loads) on the head penetrations for SONGS Units 2 and 3. The results of the evaluations are presented in terms of simple flaw tolerance charts. In support of Relaxation Request 2, the information in Sections 4, 5, 6, and Appendices B and C of WCAP-15819, Rev. 1 was used to establish the minimum required inspection distance below the toe of the weld.

Crack Growth:

The PWSCC Crack Growth Curve recommended in Materials Reliability Project (MRP)-55 Rev. 1 was used in the crack growth calculation and the vessel head temperature of 591°F for San Onofre Units 2 and 3 was considered in determining the PWSCC crack growth rate. A more detailed discussion on the development of the MRP-55 Rev.1 crack growth curve is provided in Section 4.2 of WCAP-15819 Rev. 1.

Stress Analysis:

WCAP-15819, Rev. 1 provided a discussion in Section 5 of the stress analyses performed to obtain accurate stresses in each CEDM nozzle and its immediate vicinity. To obtain these stresses, three-dimensional elastic plastic finite element analyses comprised of iso-parametric and wedge elements were performed that consider all the pertinent loadings on the penetration nozzle. These loadings included internal pressure and thermal expansion effects typical of steady state operation. In addition, residual stresses due to the welding of the penetrations to the vessel head were considered. Views of CEDM and ICI finite element models are shown in Figures 5-1 and 5-2 of WCAP-15819 Rev. 1, respectively.

Four CEDM locations were considered: the outermost row (at 49.7 degrees angular position from the RV centerline), rows at 29.1 degrees, 7.8 degrees, and the center location (0 degree). The results from these four angular positions were used to generate crack growth curves applicable to all the CEDM penetrations for San Onofre Units 2 and 3. The stress intensity factor expression used in the crack growth calculation was based on that for a through-wall flaw in a cylinder as discussed in Section 6.2 of WCAP-15819 Rev. 1.

Crack Growth Calculation:

A series of crack growth curves that characterize the growth of a through-wall flaw below the J-groove weld were generated and shown in Appendix C. These curves were used to determine the minimum required inspection coverage to ensure that any flaws initiated below the weld in the un-inspected region of the penetration nozzle would not reach the bottom of the weld in less than one operating fuel cycle. Enclosure 3, of this response, provides a detailed illustration of how the crack growth curves in Appendix C of WCAP-15819 Rev. 1 were generated. The service life shown on these crack growth curves are in Effective Full Power Years, since crack growth will only occur at operating temperatures.

Each of the figures in Section 6 and Appendix C of WCAP-15819, Rev. 1 allow the future service time to be estimated graphically, as discussed in Section 3. Results are shown for each of the penetration nozzles analyzed in each of these figures.

In each of the Section 6 and Appendix C figures, the location of the upper extremity of the postulated through-wall crack is identified on the charts by the distance measured from the bottom of the weld. The initial through-wall flaw size is determined by assuming that the lower extremity of the through-wall flaw is located on the penetration nozzle where both the inside and outside surface hoop stress in the tensile region drops below 20 ksi for Section 6 and where either the inside or outside surface hoop stress becomes compressive (0 ksi) for Appendix C. The time duration required for the upper extremity of an axial through-wall flaw to reach the bottom of the weld can be determined from these charts as shown in Example Problem 5 in Section 7.

Conservatisms:

The postulated initial crack for WCAP-15819 Rev. 1 Appendix C curves extends from the expected lower extent of the inspection coverage area to the point where hoop stresses on either the ID or the OD are no longer tensile. Both Section 6 and Appendix C use design weld sizes, which is conservative compared to the as-built weld sizes. In addition, the methodology employs multiple conservatisms as described in Enclosure 3 and ensures that any postulated cracks below the inspected region will not propagate to the toe of the weld before the next scheduled outage.

Conclusion:

Based on the technical basis presented in WCAP-15819, Rev. 1 and the crack growth curves shown in Appendix C, SCE has concluded that the requested minimum inspection coverage would ensure that any undetected cracks below the inspected region would not propagate to the toe of the weld before the next scheduled outage.

Cracks that are limited to the penetration nozzle sections below the J-groove weld do not represent a potential for leakage, damage to reactor vessel head materials, coolant loss, or consequential risk to the public. Therefore the proposed minimum inspection requirements conservatively ensure an acceptable level of quality and safety compared to that of the revised Order.

Enclosure 3

Additional Information Supporting SCE Relaxation Request 2 to First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors

<u>Sample Stress Intensity Factor Calculation for the Center Penetration (0°)</u>

Enclosure 3

Sample Stress Intensity Factor Calculation for the Center Penetration (0°)

The calculation provided below is carried out in detail, to illustrate the types of calculations that were performed to generate the crack growth curves shown in Appendix C of WCAP-15819, Rev.1. References to equation numbers and page numbers throughout this enclosure are found in WCAP-15819, Rev.1, unless otherwise noted. The crack growth curves generated can be used to establish the inspection coverage that is necessary to support a full operating cycle inspection frequency for San Onofre, Units 2 and 3.

These calculations are conservative by design. Some of the conservatisms embedded in this evaluation are listed below:

1. The flaw has been assumed to be an axial through-wall crack.

2. The length of the through-wall flaw has been assumed in Section 6.0 of WCAP-15819, Rev. 1 to extend from the region below the weld where coverage is expected to end, to a point where the hoop stress on both the inside and outside surface drops below 20 ksi. Primary Water Stress Corrosion Cracking (PWSCC) has not been observed to initiate on head penetration tubes where the stresses are below yield strength and 20 ksi is approximately half that of the yield strength. Nevertheless, in Appendix C, the initial through-wall axial flaw size is determined by conservatively postulating that the lower extremity of the flaw is located where either the inside or outside surface hoop stress drops below 0 ksi.

3. The flaw has been assumed to initiate in and propagate from a region below the proposed inspection coverage area. Flaws have never been observed in this low stress region away from the weld without the presence of other flaws in the high stressed region near the weld.

4. The stress intensity factor calculation was based on the highest stress anywhere along the postulated flaw and was applied uniformly along the entire length of the through-wall axial flaw.

The hoop stress distribution in Table 1 below was obtained from elastic plastic finite element analysis, as described in WCAP-15819, Rev.1, based on the as-designed weld configuration. These results were reported in Appendix B. In addition, Appendix B shows a comparison between the hoop stress distribution for the as-designed and as-built weld configuration. The as-built weld configuration is based on the UT data obtained from San Onofre Unit 3 and is a good representation for the as-built weld configuration in San Onofre Unit 2. The crack growth curves shown in Appendix C were generated based on the hoop stress distribution for the as-designed weld configuration. That is an additional conservatism.

The calculation process used in the generation of the Appendix C crack growth curves is shown step by step here, to enable a complete understanding, and to allow independent verification of the calculations that have been performed. The results of the sample calculation shown below and its iterations are used to generate the crack growth curve for the center penetration shown in Figure C-1 in Appendix C of WCAP-15819-P, Rev.1. The method shown in this example is the same as the method used for all penetration orientations.

Table 1: Hoop Stress Distribution Below the Weld
(Based on As-Designed Weld Configuration for the Center Penetration)

	Axial Height (in)	ID Hoop Stress (psi)	OD Hoop Stress (psi)	Avg. Hoop Stress (ksi)
Nozzle Bottom	0.000	-15,083	-12,981	-14.032
	0.348			-10.306
	0.696	-3,641	-9,519	-6.580
	0.975			0.578
	1.253	16,745	-1,272	7.736
	1.476			12.280
	1.699	28,704	4,944	16.824
	1.878			23.090
	2.057	38,459	20,252	29.356
	2.200			37.254
	2.343	39,930	50,373	45.152
	2.458			47.094
Weld Bottom	2.573	31,474	66,599	49.037

Initial Through-Wall Flaw Size Determination

Upper Extremity: End of the inspection zone (0.5" below the weld)
Lower Extremity: Zero hoop stress on either the inside or outside surface (1.229" from bottom of weld or 1.344" from nozzle bottom) [see "Design OD" curve on Figure B-1]

Initial through-wall flaw length, 2a = (1.229 – 0.500) = 0.729"

Sample Stress Intensity Factor Calculation for the Center Penetration (0°)

Stress Intensity Factor (K) Calculation for Initial Through-Wall Flaw Size:

The stress intensity factor expression used is based on that for an axial through-wall flaw in a cylinder obtained from the Stress Analysis of Cracks Handbook (2nd Edition) by Hiroshi Tada.

$K_I = \sigma \sqrt{\pi a}\ F(\lambda)$ [Equation 6-3]

where:
σ = average hoop stress through the nozzle wall thickness at the upper extremity
a = half flaw length
$\lambda = a/\sqrt{Rt}$
R = Penetration nozzle mean radius
t = Penetration nozzle wall thickness
$F(\lambda) = (1+1.25\lambda^2)^{1/2}$ for $0 < \lambda \leq 1$
$F(\lambda) = 0.6+0.9\lambda$ for $1 \leq \lambda \leq 5$

For this example:

R = [(Inside Diameter / 2)+(Outside Diameter / 2)]/2 = (2.728/2+4.050/2)/2
= 1.6945"

t = 0.661"; a = 2a/2 = 0.729"/2 = 0.364"

then $\lambda = a/\sqrt{Rt}$ = 0.364/[(1.6945)(0.661)]$^{1/2}$ = 0.344

From Table 1 on the previous page, the axial distance from bottom of the weld to the bottom of the nozzle is 2.573". The crack tip is initially postulated to be located at 0.50" below the weld, which corresponds to an axial height of the upper crack tip relative to the bottom of the nozzle of 2.073".

From Table 1, the average hoop stress at the following axial heights is:

Axial height = 2.200" σ = 37.254 ksi
Axial height = 2.057" σ = 29.356 ksi

Since the axial height of the crack tip is located at 2.073 inch from the nozzle bottom, 37.254 ksi (maximum stress in the vicinity of the upper extremity of the flaw) was applied uniformly along the entire crack length in the stress intensity factor calculation. The stress intensity factor is calculated for the initial through-wall flaw as follows:

Enclosure 3

Sample Stress Intensity Factor Calculation for the Center Penetration (0°)

Since λ is between 0 and 1.0, $F(\lambda) = (1 + 1.25\lambda^2)^{1/2}$

$$F(\lambda) = [1 + (1.25)(0.344)^2]^{1/2} = 1.0714$$

$$K_I = \sigma \sqrt{\pi a}\ F(\lambda) = (37.254\ \text{ksi})[(3.14)(0.364")]^{1/2}\,(1.0714)$$

$$K = 42.7\ \text{ksi}\sqrt{\text{in}}$$

Once K is determined, the crack growth for the initial through-wall flaw can then be calculated based on the Materials Reliability Project (MRP)-55, Rev. 1 recommended Alloy 600 crack growth rate and taking into account the head temperature (591°F) of San Onofre Unit 2. The resulting crack growth rate is as follows:

$$\frac{da}{dt} = 1.40 \times 10^{-12}\,(K - 9)^{1.16}\ \text{m/sec}$$ [see equation at the bottom of page 4-5]

An iterative process is used in generating the crack growth curves. The stress intensity factor "K" for each subsequent iterative upper crack tip location as the crack propagates is determined similar to that shown above, except that the applied hoop stress (σ) used is updated based on that at the new upper crack tip location and the half flaw length (a) is based on the new half flaw length. The hoop stress used increases as the flaw propagates upward towards the bottom of the weld as shown in the hoop stress distribution in Appendix B. A period of one month is used for each iterative step.

The crack growth below the weld can then be calculated as a function of time in Effective Full Power Years (EFPY) using the above crack growth rate by updating the stress intensity factor as the crack grows until the upper crack tip reaches the bottom of the weld. The resulting crack growth curve for the center penetration in this sample calculation is shown in Figure C-1 in Appendix C of WCAP-15819-P, Rev. 1.

Enclosure 3

Sample Stress Intensity Factor Calculation for the Center Penetration (0°)

Crack Growth Results Based on Hoop Stress from the As-Built Weld Configuration

The methodology used in generating the crack growth curves in Appendix C is used here for the 0°, 7.8°, 29.1° and 49.7° CEDM nozzles, except that the hoop stress from the as-built weld configuration instead of that from the as-designed weld configuration is used. The required time in EFPY for the upper crack tip to reach the bottom of the weld from the inspection coverages extracted from Appendix C is compared to the as-built calculation results to illustrate that conservatism.

Nozzle Angle (°)	Nozzle No.	Minimum Required Inspection Coverage Below the Weld per Appendix C curves (inches)	EFPY (App. C)	EFPY (As – Built Weld Sizes)
0	1	0.43	1.75	1.81
7.8	2-35	0.43	1.75	2.17
29.1	36-87	0.42	1.75	∞ (Note 1)
49.7	88-91	0.35	1.75	∞ (Note 1)

Note 1: Stress intensity is less than the threshold of 9 MPa$\sqrt{m}$ [K_{th} from page 4-5] and therefore will not propagate towards the bottom of the weld.

In each case, the requested relaxation results in a minimum inspection frequency that is longer than the SONGS operating cycle.

Enclosure 4

First Revised ORDER EA-03-009 Relaxation Request 2, Rev. 1

Request For Relaxation From The Requirements Of The First Revised NRC Order EA-03-009 Issued February 20, 2004 To Address Inaccessible Areas Respective To Non-Destructive Examinations

Enclosure 4

First Revised NRC ORDER (EA-03-009) Relaxation Request 2, Rev. 1

1. Components Affected

SONGS Unit 2: Ninety-one (91) Control Element Drive Mechanism (CEDM) penetrations

SONGS Unit 3: Ninety-one (91) Control Element Drive Mechanism (CEDM) penetrations

(Based on the results of the current SONGS Unit 2 inspections, Southern California Edison (SCE) no longer seeks relaxation from the requirements of the Order for the ten ICI penetrations.)

2. NRC Order Requirement

The First Revised NRC Order (EA-03-009), Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (Reference 1) established interim inspection requirements for reactor pressure vessel head (RPVH) penetrations.

Part IV.C(5)(b)(i) of the Revised EA-03-009 requires Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-1]); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-2). In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

Part IV.C(5)(b)(ii) of Revised EA-03-009 requires an Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-3]); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-4).

3. Proposed Alternative

SCE seeks relaxation from the First Revised NRC Order EA-03-009 where inspection coverage is limited by inaccessible areas of CEDM penetration nozzles with respect to nondestructive examination (NDE), including ultrasonic testing (UT), eddy current testing (ET), and dye penetrant testing (PT).

SCE proposes to meet the Order requirements, or to examine each CEDM nozzle from 2 inches above the top of the attachment weld to as far down the nozzle as physically possible. This distance shall be at least the minimum inspection distance below the bottom of the attachment weld as follows:

CEDM # 1	.44 inches below the bottom of the weld
CEDM #'s 2 through 35	.43 inches below the bottom of the weld
CEDM #'s 36 through 87	.42 inches below the bottom of the weld
CEDM #'s 87 through 91	.35 inches below the bottom of the weld

4. Reason for Relaxation Request

The material near the bottom of each CEDM nozzle cannot be inspected due to the presence of a CEDM extension shaft guide cone threaded to the ID surface. The length of the ID surface of each CEDM nozzle that cannot be inspected is approximately 1.5 inches.

A drawing showing detailed dimensions of a CEDM penetration (SO23-901-213, Rev. 1) was provided as Attachment 1 to the December 9, 2003 letter (Reference 3). In the discussions regarding distances below the J-groove weld, the J-groove weld is assumed to include the associated fillet weld. A letter dated February 9, 2004 (Reference 4), provided additional information regarding the CEDM extension shaft guide cone threads in support of this relaxation request.

5. Basis for Relaxation

The phenomenon of concern is primary water stress corrosion cracking (PWSCC), which typically initiates in the areas of highest stress. The area of CEDM penetrations that has the highest residual stress is the area adjacent to the J-groove attachment weld. Therefore, it is most probable that PWSCC will initiate adjacent to the J-groove attachment weld. PWSCC at or above the attachment weld resulting in pressure boundary leakage and the potential development of a safety concern (ejection of a nozzle or substantial corrosion of the low-alloy steel RPVH) prompted the NRC to issue Order EA-03-009. The inspections at San Onofre Nuclear Generating Station (SONGS) will ensure the integrity of the pressure boundary.

In previous NRC reviews of relaxation requests for un-inspectable areas of RPVH penetrations, the NRC has requested that an analysis be performed to characterize the potential growth of postulated cracks in the un-inspected areas. This type of analysis has been performed for SONGS Units 2 and 3. Results from the SONGS specific structural integrity evaluation of RPVH penetrations were provided in the February 9, 2004, submittal (Reference 4). This submittal included Westinghouse Report WCAP-15819, Rev. 1, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: San Onofre Units 2 and 3" (Reference 2).

The minimum inspection distance proposed for each CEDM nozzle is based on the Appendix C curves provided in WCAP-15819, Rev. 1.

The postulated initial crack for the WCAP-15819, Rev. 1, Appendix C curves extends from the expected lower extent of the inspection coverage area to the point where hoop stresses on either the ID or the OD become compressive. Appendix C crack growth curves use design weld sizes, which are conservative compared to the as-built weld sizes.

The minimum inspection coverage values that are requested are taken from the most conservative crack growth rate curves. These Appendix C curves support that a through-wall axial crack growing from minimum distance inspected for each CEDM below the weld would take at least one operating cycle to reach the bottom of the weld.

This does not include the time that would be required for an axial crack to propagate through the attachment weld and result in a leakage path. Additional operating time would be required for a safety concern (ejection of a nozzle or substantial corrosion of the low-alloy steel RPVH) to develop as a result of that leak. Therefore, multiple inspection intervals would be available to detect a flaw that initiates in the un-inspected region prior to potential development of a safety concern.

The threaded portion of the extension shaft guide cone would serve to retain potential loose parts resulting from a circumferential crack in the un-inspected area. A postulated 360-degree through wall crack in the narrow un-inspected annulus above the guide cone threads could result in separation of the guide cone from the penetration. However, in that case, the guide cone would be retained by the control element assembly (CEA) shroud and associated CEA extension shaft. This condition would not interfere with CEA function or any other reactor coolant system function, and would be readily observed in the subsequent refueling outage.

Based on a review of data acquired during the Unit 2, Cycle 12 and 13 refueling outages, examination data can be collected from 2 inches above the top of the attachment weld to at least the requested minimum distances below the bottom of the attachment weld in all 91 CEDM penetrations. The proposed inspection scope to at least the minimum distance below the attachment weld provides at least one additional inspection interval to detect cracks propagating from the un-inspected area to the bottom of the weld and multiple inspection intervals would be available to detect cracks propagating from the un-inspected area before they could develop into a safety concern.

4. Duration of Proposed Alternative

The proposed alternative will apply until rescinded by the NRC or withdrawn by SCE.

5. Precedent

Letter from Scott W. Moore (NRC) to J. A. Stall (FP&L), dated May 29, 2003; Subject: Saint Lucie Nuclear Plant, Unit 2 - Order EA-03-009 Relaxation Request Nos. 1 and 2 Regarding Examination Coverage of Reactor Pressure Vessel Head Penetration Nozzles (TAC Nos. MB8165 and MB8166)

6. References

1. First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors, issued on February 20, 2004

2. Westinghouse Report WCAP-15819-P, Rev. 1, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: San Onofre Units 2 and 3"

3. Letter from A. E. Scherer (SCE) to the Document Control Desk (NRC) Dated December 9, 2003; Subject: Docket Nos. 50-361 and 50-362, Request For Relaxation Of Reactor Pressure Vessel Head Penetration Inspection Requirements In Nuclear Regulatory Commission Order EA-03-009, San Onofre Nuclear Generating Station Units 2 and 3

4. Letter from A. E. Scherer (SCE) to the Document Control Desk (NRC) Dated February 9, 2004; Subject: Response to NRC Request for Additional Information Regarding Relaxation Requests 1 and 2 for Reactor Pressure Vessel Head Penetration Inspection Requirements in Nuclear Regulatory Commission Order EA-03-009 for San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 (TAC Nos. MC1540, MC1541, MC1542, and MC1543)